

## **DYNAMIC PRESSURE TYPE OIL-IMPREGNATED SINTERED BEARING AND MANUFACTURE THEREOF**

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Inventor(s): OKAMURA KAZUO; YAMAMOTO YASUHIRO; KOMORI ISAO; MORI NATSUHIKO; SHIRANAMI MAKOTO  
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### **Abstract**

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**PROBLEM TO BE SOLVED:** To perform molding of a bearing surface having an inclination-form dynamic groove through simple equipment with the reduced number of processes, and with high precision.

**SOLUTION:** After a sintered, metallic material 1' is registered with the upper surface of a die 20 and arranged, an upper punch 22 and a core rod 21 are lowered. The sintered metallic material 1' is pressed in a die 20 and further pressed against a lower punch 23 and pressurized from a vertical direction. The sintered metallic elements 1' receives a press force from a die 20 and upper and lower punches 22 and 23 and is brought into deformation, an inner peripheral surface is pressurized by the molding tool 21a of a core rod 21, plastic fluid is generated and bites the molding tool 21a. This constitution transfers the shape of the molding tool 21a on the inner peripheral surface of the sintered metallic material 1' and molds a bearing surface having a dynamic pressure groove.

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**Bibliography**

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[Identification Number] 000102692

[Name] ENUTIENU, Inc.

[Address] 1-3-17, Kyomachi-bori, Nishi-ku, Osaka-shi, Osaka

(72) [Inventor(s)]

[Name] Okamura The first son

[Address] 86, Matsugashima, Nagashima-cho, Kuwana-gun, Mie-ken

(72) [Inventor(s)]

[Name] Yamamoto Yasuhiro

[Address] 94-5, Sotobori, Kuwana-shi, Mie-ken

(72) [Inventor(s)]

[Name] Komori \*\*

[Address] 772-7, Harima, Kuwana-shi, Mie-ken

(72) [Inventor(s)]

[Name] Woods Natsuhiko

[Address] 541-14, Minami-Fukusaki, Kawagoe-cho, Mie-gun, Mie-ken

(72) [Inventor(s)]

[Name] White horse Sincerity

[Address] 518 of 17-1, Azabu-cho, Inazawa-shi, Aichi-ken

(74) [Attorney]

[Patent Attorney]

[Name] Ehara Shogo (outside trinominal)

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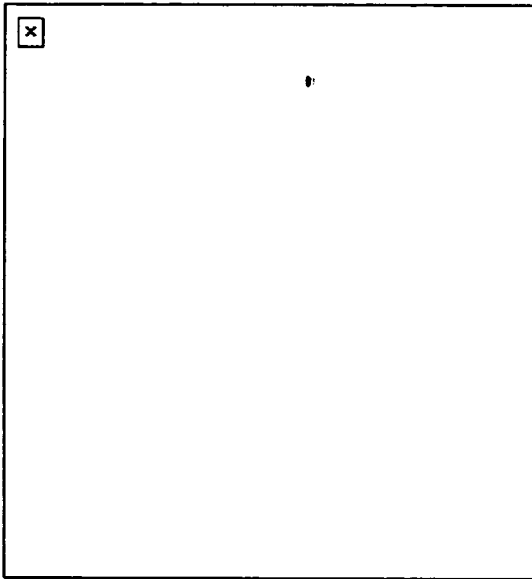
(57) [Abstract]

[Technical problem] With simple equipment, it is a small man day and fabrication of the bearing surface which has the dynamic pressure slot of the letter of an inclination is performed with a sufficient precision.

[Means for Solution] After carrying out alignment of sintered-metal material 1' to the upper surface of a die 20 and arranging it on it, top punch 22 and a core rod 21 are dropped, sintered-metal material 1' is pressed fit in a die 20, and it pushes against bottom punch 23 further, and pressurizes from the upper and lower sides. In response to pressure force, a lifting and inner skin are pressurized by die 21a of a core rod 21 in deformation from a die 20 and vertical punch 22-23, and sintered-metal material 1' starts plastic flow, and bites die 21a. Thereby, a configuration of die 21a is imprinted by inner skin of sintered-metal material 1', and the bearing surface which has a dynamic pressure slot of a letter of an inclination is fabricated.

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## CLAIMS

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[Claim(s)]

[Claim 1] A porous bearing main part with which the bearing surface which has a dynamic pressure slot of a letter of an inclination in inner skin was formed An oil held by impregnation of a lubricating oil or lubricating grease in pore inside the above-mentioned bearing main part Are the manufacture method of a dynamic pressure mold porosity oilless bearing equipped with the above, and a die which has the 2nd shaping section for fabricating the 1st shaping section for fabricating a formation field of a dynamic pressure slot in the above-mentioned bearing surface and fields other than a formation field of a dynamic pressure slot is inserted in inner skin of a cylinder-like porosity material. It is characterized by including a production

process which carries out coincidence shaping of a formation field of a dynamic pressure slot in the above-mentioned bearing surface, and the other field in inner skin of the above-mentioned porosity material by applying pressure force to the above-mentioned porosity material, and pressurizing inner skin of the above-mentioned porosity material at the above-mentioned die.

[Claim 2] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 1 that the above-mentioned porosity material is formed with a sintered metal.

[Claim 3] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 2 that the above-mentioned sintered metal uses copper, iron, or its both as a principal component.

[Claim 4] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 1, 2, or 3 which releases the above-mentioned die from mold from inner skin of the above-mentioned porosity material using springback of the above-mentioned porosity material by canceling the above-mentioned pressure force after fabricating the above-mentioned bearing surface.

[Claim 5] A porous bearing main part with which the bearing surface which has a dynamic pressure slot of a letter of an inclination in inner skin was formed An oil held by impregnation of a lubricating oil or lubricating grease in pore inside the above-mentioned bearing main part Are the manufacture method of a dynamic pressure mold porosity oilless bearing equipped with the above, and a die which has the 2nd shaping section for fabricating the 1st shaping section for fabricating a formation field of a dynamic pressure slot in the above-mentioned bearing surface and fields other than a formation field of a dynamic pressure slot is used as an inner mold. It is characterized by including a production process which carries out coincidence shaping of a formation field of a dynamic pressure slot in the above-mentioned bearing surface, and the other field in inner skin of the above-mentioned compression-molding object with the above-mentioned die at the same time it fabricates a cylinder-like compression-molding object from a powder material with compression molding.

[Claim 6] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 5 that the above-mentioned powder material is a powder metal material.

[Claim 7] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 6 that the above-mentioned powder metal material uses copper, iron, or its both as a principal component.

[Claim 8] A manufacture method of a dynamic pressure mold porosity oilless bearing according to claim 5, 6, or 7 which releases the above-mentioned die from mold from inner skin of the above-mentioned compression-molding object using springback of the above-mentioned compression-molding object by canceling compression-molding force after fabricating the above-mentioned compression-molding object.

[Claim 9] A dynamic pressure mold porosity oilless bearing manufactured by the manufacture method given in any of claim 1 – claim 8 they are.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] While this invention carries out impregnation of a lubricating oil or the lubricating grease to the bearing main part which consists of porosity objects, such as a sintered metal, and gives a self-lubrication function to it It is related with the dynamic pressure mold porosity oilless bearing which carries out non-contact support of the sliding surface of a shaft by the lubricating oil film formed of a dynamic pressure operation of a dynamic pressure slot. Especially like the device by which high rotation precision is demanded under a high speed and the spindle motors for DVD-ROM, such as a spindle motor the object for the polygon mirrors of a laser beam printer (LBP), and for magnetic disk drives (HDD etc.) When a disk appears, it is suitable for bearing, such as a device which a big imbalance load acts and is driven at high speed.

[0002]

[Description of the Prior Art] Much more improvement and low-cost-izing of rotationability are called for, and transposing bearing of a spindle to a porosity oilless bearing from anti-friction bearing is considered as a means for it by the small spindle motor of the above information-machines-and-equipment relation. However, since a porosity oilless bearing is a kind of a cylindrical bearing, when the eccentricity of a shaft is small, it has the defect which unstable oscillation tends to generate and the so-called HOWARU around which sways at the rate of one half of rotational speed, and it turns tends to generate. Then, to establish dynamic pressure slots, such as a herringbone form and a spiral form, in the bearing surface, to make a lubricating oil film form in a bearing clearance according to an operation of the dynamic pressure

slot accompanying rotation of a shaft, and to carry out non-contact support of the shaft is tried conventionally (dynamic pressure mold porosity oilless bearing).

[0003] As conventional technology in which the dynamic pressure slot was formed to the bearing surface of a porosity oilless bearing, the thing of a publication is in utility model public notice Showa 63 year 19627 No. Technology given [ this ] in a number performs surface powdery-substance-to-fling-in-the-eyes processing to the formation field of the dynamic pressure slot in the bearing surface, and seals the formation field of a dynamic pressure slot. Moreover, the method of pressurizing a ball at material inner skin and carrying out plastic working of the formation field of a dynamic pressure slot is learned, inserting in the inner skin of a bearing material the fixture of the shape of a shaft which carried out array maintenance of two or more hard balls at circumference regular intervals, and giving screw motion to a ball by rotation of a fixture and delivery rather than a bearing material, as the shaping method of the dynamic pressure slot in the bearing surface, (JP,2541208,B).

[0004]

[Problem(s) to be Solved by the Invention] The following troubles arise with the configuration indicated by utility model public notice Showa 63 year 19627 No. First, since sealing of the formation field of a dynamic pressure slot is carried out completely, in the field, circulation of the oil which is the greatest feature of a porosity oilless bearing is checked. Therefore, the oil which once oozed out to the bearing clearance will be stuffed into the shaft-orientations center section of the bearing surface by operation of a dynamic pressure slot, and will remain there according to it. Since the big shear operation within a bearing clearance is working, the oil which remained in the bearing clearance with the shearing force and frictional heat is in the orientation in which is easy to denaturalize and oxidation degradation is rash with a temperature rise. Therefore, a bearing life becomes short. Although coating besides plastic working etc. is listed next as other means to perform surface powdery-substance-to-fling-in-the-eyes processing, it is very difficult to make thickness of a coating coat thinner than a channel depth, and to give the coating coat which is several micrometers only to the formation field of a dynamic pressure slot.

[0005] Moreover, by the method indicated by JP,2541208,B, since material upheaval takes place in the field which adjoins a dynamic pressure slot at the time of shaping, it is necessary to carry out removal processing of this with a lathe or a reamer (patent public presentation 8 [ Heisei ] No. 232958 per year). Therefore, a manufacture man day increases. Moreover, since the rotation drive and delivery device of a fixture are required, a manufacturing facility becomes complicated. Furthermore, since it is necessary to fix a bearing material by the chuck, the bearing surface deforms according to the chuck force, or deviation arises in coaxiality with a peripheral face.

[0006] The purpose of this invention is to secure circulation of the suitable oil between the interior of a bearing main part and a bearing clearance, control

deterioration of the oil in a bearing clearance, and raise a bearing life while offering the manufacture method that it is simple equipment, and it is a small man day and fabrication of the bearing surface which has the dynamic pressure slot of the letter of an inclination can be performed with a sufficient precision.

[0007]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention inserts in inner skin of a cylinder-like porosity material a die which has the 2nd shaping section for fabricating the 1st shaping section for fabricating a formation field of a dynamic pressure slot in the bearing surface, and fields other than a formation field of a dynamic pressure slot. It considered as a configuration which carries out coincidence shaping of a formation field of a dynamic pressure slot in the bearing surface, and the other field at inner skin of a porosity material by applying pressure force to a porosity material and pressurizing inner skin of a porosity material at a die. Or while fabricating a cylinder-like compression-molding object from a powder material with compression molding by using the above-mentioned die as an inner mold, it considered as a configuration which carries out coincidence shaping of a formation field of a dynamic pressure slot in the bearing surface, and the other field with a die at inner skin of a compression-molding object. Mold release of the above-mentioned die can be performed using springback of a compression-molding object by canceling compression-molding force, using springback of a porosity material by canceling the above-mentioned pressure force.

[0008]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained.

[0009] Drawing 1 has illustrated one gestalt of the dynamic pressure mold porosity oilless bearing manufactured by the manufacture method of this invention. This porosity oilless bearing 1 enables non-contact support of the rotation of the spindle shaft 4 which carries out high-speed rotation by the example magnetism between Rota 2 and a stator to housing 5 in the scanner motor of a laser beam printer as shown in drawing 2.

[0010] The porosity oilless bearing 1 consists of porous bearing main part 1a and an oil held by the impregnation of a lubricating oil or lubricating grease in the pore of bearing main part 1a. For bearing main part 1a, it is formed with copper, iron, or the sintered metal that uses the both as a principal component, copper is contained 20 to 95% of the weight desirably, and density is 3.64–7.2g/cm. It is formed so that it may become. As the quality of the material of bearing main part 1a, what used cast iron, synthetic resin, the ceramics, etc. as sintering or the porosity object which carries out foaming and has much pores may be used.

[0011] Bearing surface 1b which counters the inner skin of bearing main part 1a through the peripheral face and bearing clearance of a shaft which should be supported is formed, and dynamic pressure slot 1c of the letter of an inclination is formed in the bearing surface 1b. The 1st field m1 which arranged two or more



dynamic pressure slot 1c toward which bearing surface 1b in this operation gestalt inclined in one side to shaft orientations to the circumferential direction, It is isolated from the 1st field m1 to shaft orientations, and consists of annular smooth fields n located between the 2nd field m2 which arranged two or more dynamic pressure slot 1c which inclined on another side to shaft orientations to the circumferential direction, and the 1st field m1 and the 2nd field m2. The back of 1d of the 1st field m1 (field between dynamic pressure slot 1c) and the back of 1d of the 2nd field m2 (field between dynamic pressure slot 1c) are following the smooth field n, respectively. Dynamic pressure slot 1c of the 1st field m1 and dynamic pressure slot 1c of the 2nd field m2 are bilateral symmetry to the shaft-orientations center line of bearing surface 1b. Surface puncturing is distributed over bearing surface 1b over all fields including the formation field of dynamic pressure slot 1c, an oil is mainly circulated between the interior of bearing main part 1a, and a bearing clearance through surface puncturing of bearing surface 1b, and it has composition which carries out non-contact support of the peripheral face of a shaft to bearing surface 1b. for example, surface hole density -- the 1st field m1 and the 2nd field m2 -- setting -- 5 - 40% of range -- desirable -- 5 - 20% of range -- setting up -- the smooth field n -- setting -- 2 - 30% of range -- it can be desirably set as 2 - 10% of range. Moreover, surface hole density of the smooth field n can be made smaller than the surface hole density of the 1st field m1 and the 2nd field m2. Here, the area rate of surface puncturing that say the portion to which the pore of porosity body tissue carried out the opening of "the surface puncturing" to the outside surface, and "surface hole density" occupies it in the unit area of an outside surface is said.

[0012] If relative rotation arises between bearing main part 1a and a shaft, since the oil in a bearing clearance will be drawn in the 1st field m1 and the 2nd field m2 by the reverse sense towards the smooth field n by dynamic pressure slot 1c by which inclination formation was carried out, respectively and an oil will be brought together in the smooth field n, the oil film pressure in the smooth field n is heightened.

Therefore, the formation effect of a lubricating oil film is high. And since it becomes the back face to which the smooth field n supports a shaft in addition to the back of 1d, a back-face product is expanded and bearing rigidity is raised. The ratio r of the shaft-orientations width of face of the smooth field n is good desirably the range of  $r=0.1-0.6$ , and to set it as the range of  $r=0.2-0.4$ , when bearing width of face is set to 1. In addition, the continuation configuration of shaft orientations as shown in drawing 3 is [ that what is necessary is just the configuration which inclined to shaft orientations ] sufficient as dynamic pressure slot 1c, or a spiral configuration is sufficient as it (it does not have an annular smooth field in this case.).

[0013] Drawing 4 shows the flow of the oil O in the shaft-orientations cross section at the time of supporting a shaft 4 by the porosity oilless bearing 1 of the above-mentioned configuration. With rotation of a shaft 4, the oil O held in the pore inside bearing main part 1a oozes out to a bearing clearance from shaft-orientations both

sides and near the chamfer section bearing surface 1b, and is further drawn by the dynamic pressure slot towards the center of shaft orientations of a bearing clearance. The pressure of the oil film by which it is placed between bearing clearances is heightened by drawing-in operation (dynamic pressure operation) of the oil O, and a lubricating oil film is formed of it. With the lubricating oil film (lubricating oil film formed of a dynamic pressure operation of a dynamic pressure slot) formed in this bearing clearance, non-contact support of the shaft 4 is carried out to bearing surface 1b, without producing unstable oscillation, such as HOWARU. With the developed pressure accompanying rotation of a shaft 4, the oil O which oozed out to the bearing clearance mainly circulates through the interior of return and bearing main part 1a inside bearing main part 1a from surface puncturing of bearing surface 1b, and oozes out from bearing surface 1b and near the chamfer section to a bearing clearance again.

[0014] Bearing main part 1a of the porosity oilless bearing 1 shown in drawing 1 can press copper, iron, or the metal powder that uses the both as a principal component, and can perform and manufacture sizing → rotation sizing → bearing surface fabrication as opposed to sintered-metal material 1' of the shape of a cylindrical shape as shown in drawing 12 which calcinated further and was obtained.

[0015] A sizing production process is a production process which performs sizing of the peripheral face of sintered-metal material 1', and inner skin, and it presses a sizing pin (cross-section round shape) fit in inner skin while it presses the peripheral face of sintered-metal material 1' fit in a cylinder-like die. A rotation sizing production process is a production process which performs sizing of inner skin, pressing fit in the inner skin of sintered-metal material 1' the sizing pin (cross section thing which carried out flat processing of the peripheral face of a circular pin partially, and left the circle portion to \*\*\*\*\*, such as the circumference) of a cross-section abbreviation polygon, and rotating this. A bearing surface forming cycle is a production process which carries out coincidence shaping of the formation field of dynamic pressure slot 1c of bearing surface 1b, and the other field (the back of 1d, and the annular smooth field n) by pressurizing the die of the configuration corresponding to bearing surface 1b of finished-product 1a at the inner skin of sintered-metal material 1' which performed the above sizing processings. This production process is as follows, for example.

[0016] Drawing 5 has illustrated the outline structure of the shaping equipment used by the bearing surface forming cycle. this -- equipment -- a sintered metal -- a material -- one -- ' -- a peripheral face -- pressing fit -- a cylinder -- \*\* -- a die -- 20 -- a sintered metal -- a material -- one -- ' -- inner skin -- fabricating -- a core rod -- 21 -- a sintered metal -- a material -- one -- ' -- both ends -- a field -- the upper and lower sides -- a direction -- from -- pressing down -- the upper and lower sides -- punch -- 22 -- 23 -- being main -- an element -- \*\*\*\*\* -- constituting -- having . As shown in drawing 5 (b), die 21a of the shape of irregularity corresponding to the configuration of bearing surface 1b of a finished

product is prepared in the peripheral face of a core rod 21. The amount of [ of die 21a / 21a1 ] heights fabricate the field of dynamic pressure slot 1c in bearing surface 1b, and the amount of [ 21a2 ] crevice fabricates fields other than dynamic pressure slot 1c (the back of 1d, and the annular smooth field n). Although the level difference (depth H) for a part for the heights 21a1 in die 21a and a crevice 21a2 is comparable (for example, about 2–5 micrometers) as the depth of dynamic pressure slot 1c in bearing surface 1b and minute, in the drawing, it exaggerates considerably and it is illustrated.

[0017] In the condition before the press fit to a die 20, the bore crevice T is between the inner skin of sintered-metal material 1', and die 21a (they are criteria about a part for heights 21a1) of a core rod 21. The magnitude of the bore crevice T (the amount of diameters) is 50 micrometers. The press fit cost (outer-diameter interference S: the amount of diameters) to the die 20 of the peripheral face of sintered-metal material 1' is 150 micrometers.

[0018] After carrying out alignment of sintered-metal material 1' to the upper surface of a die 20 and arranging it on it, as shown in drawing 6, top punch 22 and a core rod 21 are dropped, sintered-metal material 1' is pressed fit in a die 20, and it pushes against bottom punch 23 further, and pressurizes from the upper and lower sides.

[0019] As for sintered-metal material 1', in response to the pressure force, a lifting and inner skin are pressurized by die 21a of a core rod 21 in deformation from a die 20 and vertical punch 22–23. The outer-diameter interference S and the surface portion from inner skin to the predetermined depth which spreads abbreviation etc. on a difference with the bore crevice T are pressurized by die 21a of a core rod 21, and the amount of pressurization of inner skin starts plastic flow, and bites die 21a. Thereby, the configuration of die 21a is imprinted by the inner skin of sintered-metal material 1', and bearing surface 1b is fabricated by the configuration and size which are shown in drawing 1 (sizing also of the peripheral face of sintered-metal material 1' is carried out to coincidence.).

[0020] After shaping of bearing surface 1b is completed, as shown in drawing 9, in the condition [ having inserted the core rod 21 in sintered-metal material 1' ], it interlocks, bottom punch 23 and a core rod 21 are raised (condition of drawing 9 \*\*), and sintered-metal material 1' is extracted from a die 20 (condition of drawing 9 \*\*). A core rod 21 can be sampled from the inner skin of sintered-metal material 1', without breaking down dynamic pressure slot 1c, since springback will arise in sintered-metal material 1' and the inside diameter will be expanded (refer to drawing 7), if sintered-metal material 1' is extracted from a die 20 (condition of drawing 9 \*\*). Thereby, bearing main part 1a is completed. in addition, in the manufacturing process of the usual cylindrical bearing (oil impregnated sintered bearing which does not have a dynamic pressure slot in the bearing surface) a condition [ having pressed sintered-metal material 1' fit in die 20', after performing sizing of the bearing surface (inner skin), as shown in drawing 8 ] -- sizing pin 21' -- {cross-

section circular: -- it does not have die 21a as shown in drawing 5 (b). It is made to go up and extracts from the inner skin of sintered-metal material 1'', and he pushes up sintered-metal material 1'' by bottom punch 23', and is trying to take out from die 20' after that. If this procedure is used for shaping of the bearing surface which has the dynamic pressure slot of the letter of an inclination, in case a sizing pin (core rod) will be sampled from the inner skin of a sintered-metal material, the configuration of a dynamic pressure slot will be broken down.

[0021] Relation with the bore crevice T, and the outer-diameter interference S and the amount of springbacks when performing the bearing surface forming cycle mentioned above to with bore phi 3, outer-diameter phi 6, and a width of face of 3mm sintered-metal material 1' to drawing 10 is shown. If a fixed correlation is between the bore crevice T, and the outer-diameter interference S and the amount of springbacks and the bore crevice T and the outer-diameter interference S are specified as shown in this drawing, you can understand that the amount of springbacks at that time is also specified. since according to the experiment sintered-metal material 1' was sampled from the core rod 21 in predetermined depth H (the depth of dynamic pressure slot 1c and abbreviation of which 2 micrometers - 3 micrometer:shaping is done -- equal.), without breaking down dynamic pressure slot 1c when setting the amount of springbacks as 4-5-micrometer (amount of diameters) degree, it is desirable to set up the bore crevice T and the outer-diameter interference S so that the amount of springbacks of this amount may be obtained. In addition, although it can release from mold without making die 21a interfere in the inner skin of sintered-metal material 1' when the amount of radii of the amount of springbacks of sintered-metal material 1' is larger than depth H Even if the amount of radii of the amount of springbacks of sintered-metal material 1' is smaller than depth H and it is the case where die 21a interferes in the inner skin of sintered-metal material 1' somewhat What is necessary is to add the amount of diameter expansion by the material elasticity of sintered-metal material 1' (the amount of radii), and just to be able to release die 21a from mold from the inner skin of sintered-metal material 1', without breaking down dynamic pressure slot 1c. Therefore, a size setup based on the above-mentioned experimental result is an example, and this invention is not restrictively interpreted by this.

[0022] In addition, after the forming cycle of bearing surface 1b is completed, you may size bearing surface 1b using the usual sizing pin (cross-section round shape). In this case, the surface hole density of these fields becomes smaller than the surface hole density of the formation field of dynamic pressure slot 1c by carrying out sizing of the back of 1d and the smooth field n in bearing surface 1b by the sizing pin. Moreover, in the forming cycle of the bearing surface, it is also possible to fabricate only the formation field of a dynamic pressure slot with a die, and to finish fields other than the formation field of a dynamic pressure slot after that by sizing (cross section a circular sizing pin use) or rotation sizing (cross section the sizing pin which carried out flat processing of the peripheral face of a circular pin partially,

and left the circle portion to \*\*\*\*\*, such as the circumference, use).

[0023] Bearing main part 1a is manufactured through the above production processes, and if impregnation of a lubricating oil or the lubricating grease is carried out to this and an oil is made to hold, the dynamic pressure mold porosity oilless bearing 1 of the gestalt shown in drawing 1 will be completed.

[0024] The comparative experiments of the axial deflection engine performance were conducted using the cylindrical bearing (oil impregnated sintered bearing which does not have a dynamic pressure slot in the bearing surface), and the dynamic pressure mold porosity oilless bearing (oil impregnated sintered bearing) manufactured by the above-mentioned method. An experiment includes trial bearing in a CD-ROM system motor as shown in drawing 13, mounts commercial CD, and measures the axial deflection over a rotational frequency. The result is shown in drawing 11. Compared with a cylindrical bearing, he can understand that the dynamic pressure mold porosity oilless bearing of an operation gestalt is effective in control of an axial deflection also from this drawing.

[0025] The above-mentioned operation gestalt can also perform bearing surface shaping in a foaming production process, although bearing surface shaping is performed to sintered-metal material 1'. After foaming inserts the foaming pin used as an inner mold inside a dies body and is filled up with a powder material between an inner mold and a dies body, it is a production process which carries out pressurization compression at shaft orientations and which is fabricated in the shape of a cylinder. In this foaming production process, the bearing surface of a configuration as shown [ foaming and coincidence ] in the inner skin of mold goods (compression-molding object) at drawing 1 can be fabricated by forming the die as shown in the peripheral face of a foaming pin at drawing 5 (b). Moreover, if the compression-molding force is removed after pressurization compression, mold goods (compression-molding object) can be extracted from a foaming pin using the springback of mold goods (compression-molding object), and the configuration of the bearing surface will not collapse at this time. A powder material is a metal powder material, for example, uses copper, iron, or its both as a principal component. The mold goods after foaming are produced commercially through a sizing production process, the impregnation production process of an oil, etc., after calcinating.

[0026] Although the case where the die of the bearing surface is released from mold using the springback of a porosity material or a compression-molding object is illustrated in the above explanation, a die is elastically made into the structure in which \*\*\*\*\* is possible (for example, let a die be the block construction by the slit.), and the diameter of a die is made to reduce elastically and you may make it release it from mold after shaping of the bearing surface. Moreover, according to the configuration (configuration of a dynamic pressure slot) of the bearing surface, the bearing surface of various configurations can be similarly fabricated by changing the configuration of a die. Furthermore, also when it is isolated to shaft orientations and forms two or more bearing surfaces in the inner skin of one bearing main part,

coincidence shaping of two or more bearing surfaces can be carried out by using for a peripheral face the core rod and foaming pin which isolated and formed two or more dice in shaft orientations.

[0027]

[Effect of the Invention] Since coincidence shaping of all the fields of the bearing surface is carried out using the die which has the 2nd shaping section for fabricating the 1st shaping section for fabricating the formation field of a dynamic pressure slot, and fields other than the formation field of a dynamic pressure slot according to this invention, with simple equipment, it is a small man day and fabrication of the bearing surface which has the dynamic pressure slot of the letter of an inclination can be performed with a sufficient precision. Moreover, since it is also possible to perform foaming of a bearing main part and bearing surface shaping to coincidence, it is advantageous also in respect of improvement in productivity, and cost reduction.

[0028] While the dynamic pressure mold porosity oilless bearing manufactured by the manufacture method of this invention has a high shaping precision of the bearing surface, its formation effect of a lubricating oil film is high since surface puncturing is distributed over all the fields of the bearing surface which moreover includes the formation field of a dynamic pressure slot and circulation of the suitable oil between the interior of a bearing main part and a bearing clearance is secured, and it has fitness and the stable bearing function, it has a high endurance life.

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[Translation done.]

**\* NOTICES \***

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2.\*\*\*\* shows the word which can not be translated.

3.In the drawings, any words are not translated.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the drawing of longitudinal section showing one gestalt of the dynamic pressure mold porosity oilless bearing manufactured by the manufacture method of an operation gestalt.

[Drawing 2] It is the drawing of longitudinal section showing the motor incorporating a porosity oilless bearing notionally.

[Drawing 3] It is the drawing of longitudinal section showing other operation gestalten of a dynamic pressure mold porosity oilless bearing.

[Drawing 4] It is drawing showing typically the flow of the oil in the shaft-orientations cross section at the time of carrying out non-contact support of the shaft by the dynamic pressure mold porosity oilless bearing.

[Drawing 5] The drawing of longitudinal section showing the outline of the shaping equipment which uses drawing 5 (a) for the fabrication of the bearing surface, and drawing 5 (b) are the side elevations showing the die which fabricates the bearing surface.

[Drawing 6] It is drawing showing the forming cycle of the bearing surface.

[Drawing 7] It is drawing showing the forming cycle of the bearing surface.

[Drawing 8] It is drawing showing the forming cycle of the bearing surface in the conventional cylindrical bearing.

[Drawing 9] It is drawing showing the forming cycle of the bearing surface of an operation gestalt.

[Drawing 10] It is drawing showing the relation between a bore crevice and an outer-diameter crevice, and the amount of springbacks.

[Drawing 11] It is drawing showing the result of having carried out the comparative study of the axial deflection at the time of using the conventional cylindrical bearing and the dynamic pressure mold porosity oilless bearing of an operation gestalt.

[Drawing 12] It is the drawing of longitudinal section showing a sintered-metal material.

[Drawing 13] It is the drawing of longitudinal section showing notionally the experimental device used for the comparative study of an axial deflection.

[Description of Notations]

1 Dynamic Pressure Mold Porosity Oilless Bearing

1a Bearing main part

1b Bearing surface

1c Dynamic pressure slot

21a Die

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[Translation done.]

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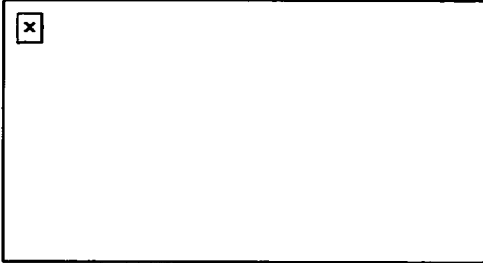
3.In the drawings, any words are not translated.

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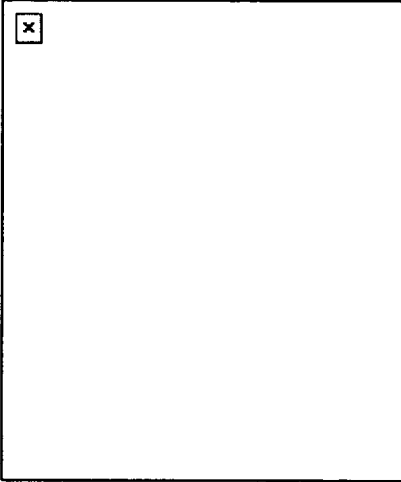
## DRAWINGS

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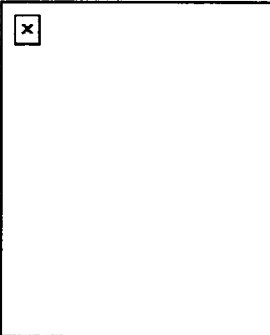
[Drawing 1]



[Drawing 2]

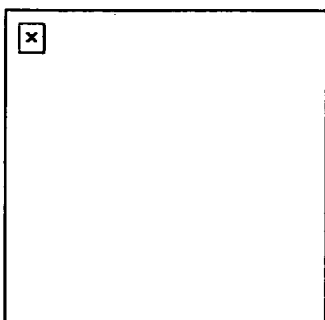


[Drawing 3]

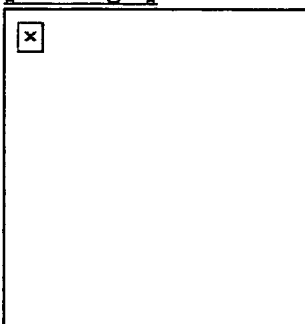


[Drawing 4]

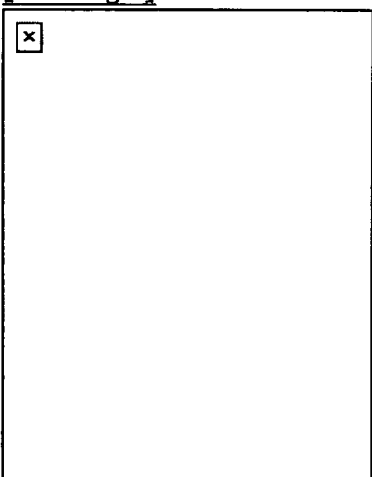




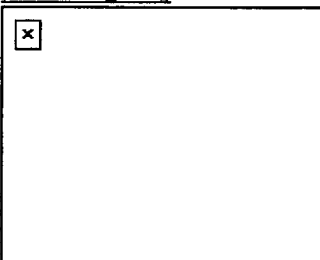
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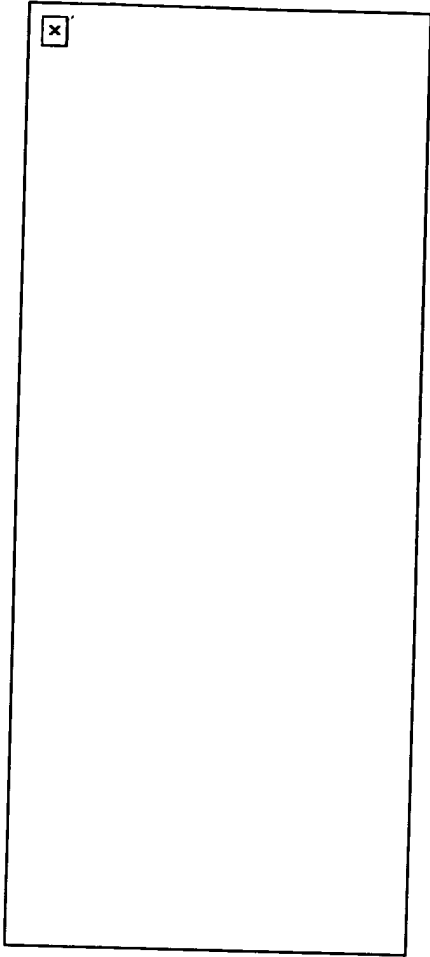
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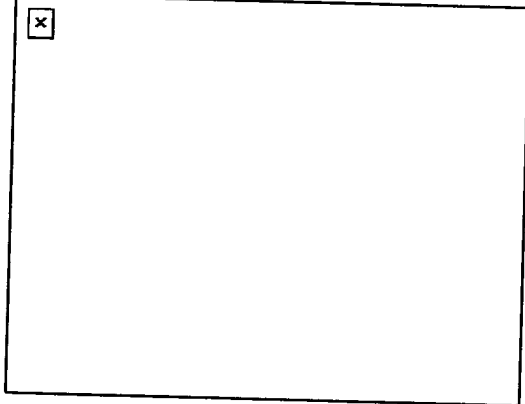
[Drawing 12]



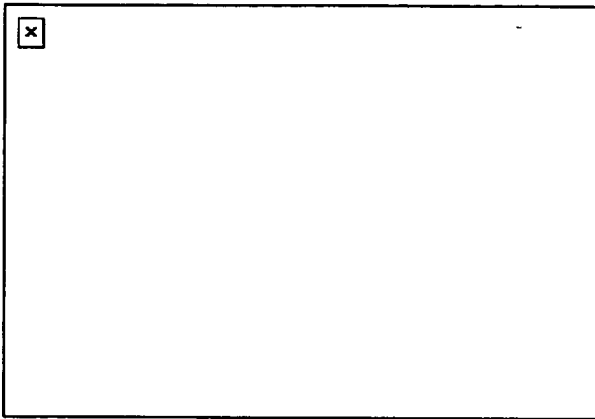
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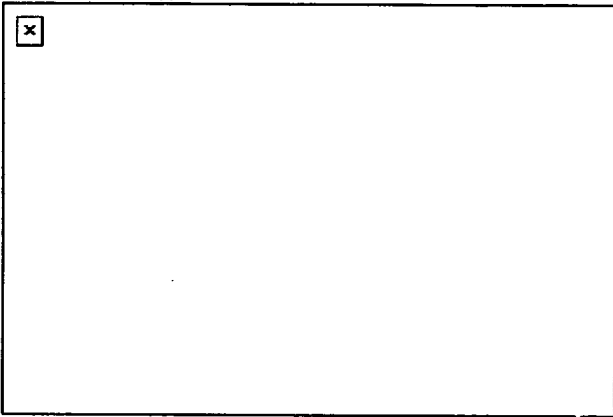
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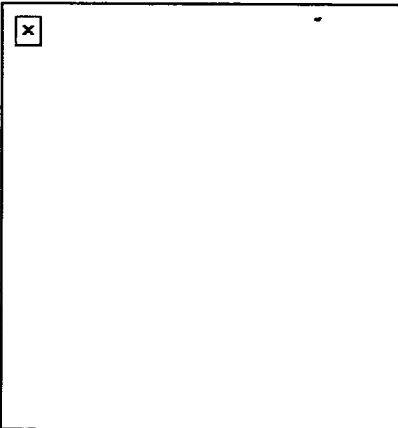
[Drawing 9]



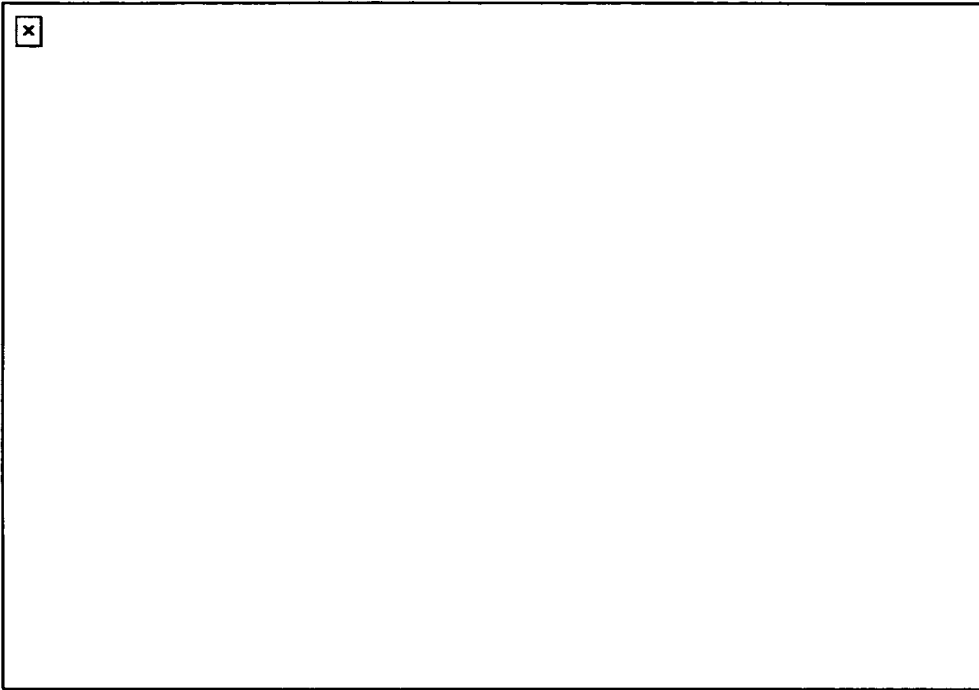
[Drawing 10]



[Drawing 13]



[Drawing 11]



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[Translation done.]

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(71) 出願人 000102692

エヌティエヌ株式会社

大阪府大阪市西区京町堀1丁目3番17号

(72) 発明者 岡村 一男

三重県桑名郡長島町松ヶ島86

(72) 発明者 山本 康裕

三重県桑名市外堀94-5

(72) 発明者 古森 功

三重県桑名市大字播磨772番地の7

(72) 発明者 森 夏比古

三重県三重郡川越町大字南福崎541-14

(72) 発明者 白波 誠

愛知県稲沢市朝府町17番地1号の518

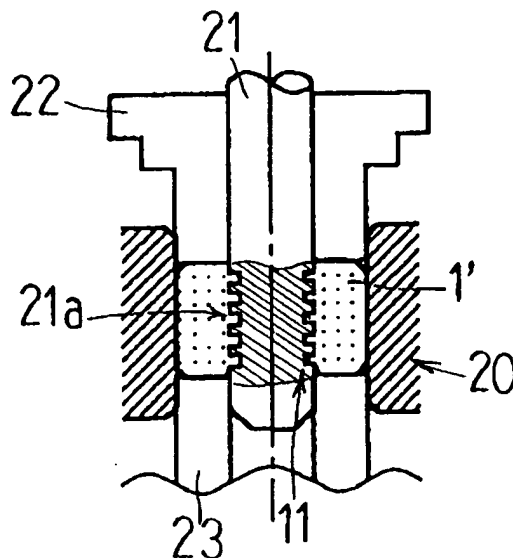
(74) 代理人 弁理士 江原 省吾 (外3名)

(54) 【発明の名称】 動圧型多孔質含油軸受およびその製造方法

(57) 【要約】

【課題】 傾斜状の動圧溝を有する軸受面の成形加工を簡易な設備で、少ない工数で、かつ、精度良く行う。

【解決手段】 焼結金属素材1'をダイ20の上面に位置合わせして配置した後、上パンチ22およびコアロッド21を降下させ、焼結金属素材1'をダイ20に圧入し、さらに下パンチ23に押し付けて上下方向から加圧する。焼結金属素材1'はダイ20と上下パンチ22・23から圧迫力を受けて変形を起こし、内周面がコアロッド21の成形型21aに加圧され、塑性流動を起こして成形型21aに食い付く。これにより、成形型21aの形状が焼結金属素材1'の内周面に転写され、傾斜状の動圧溝を有する軸受面が成形される。



## 【特許請求の範囲】

【請求項1】 内周面に傾斜状の動圧溝を有する軸受面が形成された多孔質の軸受本体と、潤滑油又は潤滑グリースの含浸によって上記軸受本体の内部の細孔内に保有された油とを備えた動圧型多孔質含油軸受を製造するための方法であって、

上記軸受面における動圧溝の形成領域を成形するための第1成形部と動圧溝の形成領域以外の領域を成形するための第2成形部とを有する成型型を円筒状の多孔質素材の内周面に挿入し、上記多孔質素材に圧迫力を加え、上記多孔質素材の内周面を上記成型型に加圧することにより、上記多孔質素材の内周面に、上記軸受面における動圧溝の形成領域とそれ以外の領域とを同時成形する工程を含むことを特徴とする動圧型多孔質含油軸受の製造方法。

【請求項2】 上記多孔質素材が焼結金属で形成されている請求項1記載の動圧型多孔質含油軸受の製造方法。

【請求項3】 上記焼結金属が銅または鉄、あるいは、その両者を主成分とする請求項2記載の動圧型多孔質含油軸受の製造方法。

【請求項4】 上記軸受面を成形した後、上記圧迫力を解除することによる上記多孔質素材のスプリングバックを利用して、上記成型型を上記多孔質素材の内周面から離型する請求項1、2又は3記載の動圧型多孔質含油軸受の製造方法。

【請求項5】 内周面に傾斜状の動圧溝を有する軸受面が形成された多孔質の軸受本体と、潤滑油又は潤滑グリースの含浸によって上記軸受本体の内部の細孔内に保有された油とを備えた動圧型多孔質含油軸受を製造するための方法であって、

上記軸受面における動圧溝の形成領域を成形するための第1成形部と動圧溝の形成領域以外の領域を成形するための第2成形部とを有する成型型を内型として、圧縮成形により粉末材料から円筒状の圧縮成形体を成形すると同時に、上記成型型により、上記圧縮成形体の内周面に、上記軸受面における動圧溝の形成領域とそれ以外の領域とを同時成形する工程を含むことを特徴とする動圧型多孔質含油軸受の製造方法。

【請求項6】 上記粉末材料が粉末金属材料である請求項5記載の動圧型多孔質含油軸受の製造方法。

【請求項7】 上記粉末金属材料が銅または鉄、あるいは、その両者を主成分とする請求項6記載の動圧型多孔質含油軸受の製造方法。

【請求項8】 上記圧縮成形体を成形した後、圧縮成形力を解除することによる上記圧縮成形体のスプリングバックを利用して、上記成型型を上記圧縮成形体の内周面から離型する請求項5、6又は7記載の動圧型多孔質含油軸受の製造方法。

【請求項9】 請求項1～請求項8の何れかに記載の製造方法によって製造された動圧型多孔質含油軸受。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、焼結金属等の多孔質体からなる軸受本体に潤滑油あるいは潤滑グリースを含浸させて自己潤滑機能を持たせると共に、動圧溝の動圧作用によって形成される潤滑油膜で軸の摺動面を非接触支持する動圧型多孔質含油軸受に関し、特にレーザービームプリンタ(LBP)のポリゴンミラー用や磁気ディスクドライブ(HDD等)用のスピンドルモータなど、高速で高回転精度が要求される機器や、DVD-ROM用のスピンドルモータのように、ディスクが載ることによって大きなアンバランス荷重が作用し高速で駆動する機器などの軸受に好適である。

## 【0002】

【従来の技術】上記のような情報機器関連の小型スピンドルモータでは、回転性能のより一層の向上と低コスト化が求められており、そのための手段として、スピンドルの軸受部を転がり軸受から多孔質含油軸受に置き換えることが検討されている。しかし、多孔質含油軸受は、真円軸受の一種であるため、軸の偏心が小さいところでは、不安定振動が発生しやすく、回転速度の1/2の速度で振れ回るいわゆるホワールが発生しやすい欠点がある。そこで、軸受面にヘリングボーン形やスパイラル形などの動圧溝を設け、軸の回転に伴う動圧溝の作用によって軸受隙間に潤滑油膜を形成させて軸を非接触支持することが従来より試みられている(動圧型多孔質含油軸受)。

【0003】多孔質含油軸受の軸受面に動圧溝を形成した従来技術としては、実用新案公告昭和63年19627号に記載のものがある。同号記載の技術は、軸受面における動圧溝の形成領域に表面目つぶし加工を施して、動圧溝の形成領域を封孔したものである。また、軸受面における動圧溝の成形方法として、軸受素材よりも硬質の複数のボールを円周等間隔に配列保持した軸状の治具を軸受素材の内周面に挿入し、治具の回転と送りによってボールに螺旋運動を与えながら、ボールを素材内周面に加圧して動圧溝の形成領域を塑性加工する方法が知られている(特許2541208号)。

## 【0004】

【発明が解決しようとする課題】実用新案公告昭和63年19627号に記載された構成では、次のような問題点が生じる。まず、動圧溝の形成領域が完全に封孔されているので、その領域では多孔質含油軸受の最大の特徴である油の循環が阻害される。従って、一旦軸受隙間にしみ出した油は動圧溝の作用によって軸受面の軸方向中央部に押し込まれ、そこにとどまることになる。軸受隙間内では大きな剪断作用が働いているので、その剪断力と摩擦熱によって軸受隙間内にとどまった油は変性しやすく、また、温度上昇によって酸化劣化が早まる傾向にある。従って、軸受寿命が短くなる。つぎに、表面目つ

ぶし加工を施す他の手段として塑性加工の他、コーティング等を挙げているが、コーティング被膜の厚さは溝深さよりも薄くする必要があり、数 $\mu\text{m}$ のコーティング被膜を動圧溝の形成領域にのみ施すのは極めて困難である。

【0005】また、特許2541208号に記載された方法では、成形時に動圧溝に隣接する領域で素材隆起が起こるので、これを旋盤やリーマで除去加工する必要がある（特許公開平成8年232958号）。そのため、製造工数が多くなる。また、治具の回転駆動機構と送り機構が必要であるため、製造設備が複雑になる。さらに、軸受素材をチャックで固定する必要があるため、チャック力によって軸受面が変形したり、外周面との同軸度に狂いが生じたりする。

【0006】本発明の目的は、傾斜状の動圧溝を有する軸受面の成形加工を簡易な設備で、少ない工数で、かつ、精度良く行うことができる製造方法を提供すると共に、軸受本体の内部と軸受隙間との間の適切な油の循環を確保し、軸受隙間内の油の劣化を抑制して軸受寿命を向上させることにある。

【0007】

【課題を解決するための手段】上記目的を達成するため、本発明は、軸受面における動圧溝の形成領域を成形するための第1成形部と動圧溝の形成領域以外の領域を成形するための第2成形部とを有する成型型を円筒状の多孔質素材の内周面に挿入し、多孔質素材に圧迫力を加え、多孔質素材の内周面を成型型に加圧することにより、多孔質素材の内周面に、軸受面における動圧溝の形成領域とそれ以外の領域とを同時成形する構成とした。あるいは、上記成型型を内型として、圧縮成形により粉末材料から円筒状の圧縮成形体を成形すると同時に、成型型により、圧縮成形体の内周面に、軸受面における動圧溝の形成領域とそれ以外の領域とを同時成形する構成とした。上記成型型の離型は、上記圧迫力を解除することによる多孔質素材のスプリングバックを利用して、あるいは、圧縮成形力を解除することによる圧縮成形体のスプリングバックを利用して行うことができる。

【0008】

【発明の実施の形態】以下、本発明の実施形態について説明する。

【0009】図1は、本発明の製造方法によって製造した動圧型多孔質含油軸受の一形態を例示している。この多孔質含油軸受1は、例えば、図2に示すようなレーザービームプリンタのスキヤナモータにおいて、ロータ2とステータとの間の例磁力によって高速回転するスピンドル軸4をハウジング5に対して回転自在に非接触支持するものである。

【0010】多孔質含油軸受1は、多孔質の軸受本体1aと、潤滑油又は潤滑グリースの含浸によって軸受本体1aの細孔内に保有された油とで構成される。軸受本体

1aは、例えば銅又は鉄、あるいはその両者を主成分とする焼結金属で形成され、望ましくは銅を20～95重量%含有し、密度が6.4～7.2 $\text{g}/\text{cm}^3$ となるように形成される。軸受本体1aの材質として、鋳鉄、合成樹脂、セラミックスなどを焼結または発泡成形し、多数の細孔を有する多孔質体としたものを用いても良い。

【0011】軸受本体1aの内周面には、支持すべき軸の外周面と軸受隙間を介して対向する軸受面1bが形成され、その軸受面1bに傾斜状の動圧溝1cが形成されている。この実施形態における軸受面1bは、軸方向に対して一方に傾斜した複数の動圧溝1cを円周方向に配列した第1領域m1と、第1領域m1から軸方向に離隔し、軸方向に対して他方に傾斜した複数の動圧溝1cを円周方向に配列した第2領域m2と、第1領域m1と第2領域m2との間に位置する環状の平滑領域nとで構成される。第1領域m1の背（動圧溝1c間の領域）1dと第2領域m2の背（動圧溝1c間の領域）1dは、それぞれ平滑領域nに連続している。第1領域m1の動圧溝1cと第2領域m2の動圧溝1cとは、軸受面1bの軸方向中心線に対して左右対称になっている。軸受面1bには、動圧溝1cの形成領域を含む全領域にわたって表面開孔が分布しており、主に軸受面1bの表面開孔を介して、軸受本体1aの内部と軸受隙間との間で油を循環させて、軸の外周面を軸受面1bに対して非接触支持する構成になっている。例えば、表面開孔率は、第1領域m1および第2領域m2において5～40%の範囲、望ましくは5～20%の範囲に設定し、平滑領域nにおいて2～30%の範囲、望ましくは2～10%の範囲に設定することができる。また、平滑領域nの表面開孔率は、第1領域m1および第2領域m2の表面開孔率よりも小さくすることができる。ここで、「表面開孔」とは、多孔質体組織の細孔が外表面に開口した部分をいい、「表面開孔率」とは、外表面の単位面積内に占める表面開孔の面積割合をいう。

【0012】軸受本体1aと軸との間に相対回転が生じると、第1領域m1と第2領域m2にそれぞれ逆向きに傾斜形成された動圧溝1cによって、軸受隙間内の油が平滑領域nに向けて引き込まれ、油が平滑領域nに集められるため、平滑領域nにおける油膜圧力が高められる。そのため、潤滑油膜の形成効果が高い。しかも、背1dに加え、平滑領域nも軸を支持する支持面になるので、支持面積が拡大し、軸受剛性が高められる。平滑領域nの軸方向幅の比率rは、軸受幅を1とした場合、 $r=0.1\sim0.6$ の範囲、望ましくは、 $r=0.2\sim0.4$ の範囲に設定するのが良い。尚、動圧溝1cは軸方向に対して傾斜した形状であれば良く、例えば図3に示すような軸方向の連続形状でも良いし（この場合、環状の平滑領域は有しない。）、あるいは、スパイラル形状でも良い。

【0013】図4は、上記構成の多孔質含油軸受1で軸

4を支持する際における、軸方向断面での油Oの流れを示している。軸4の回転に伴い、軸受本体1aの内部の細孔内に保有された油Oが軸受面1bの軸方向両側及びチャンファ一部付近から軸受隙間にしみ出し、さらに動圧溝によって軸受隙間の軸方向中央に向けて引き込まれる。その油Oの引き込み作用（動圧作用）によって軸受隙間に介在する油膜の圧力が高められ、潤滑油膜が形成される。この軸受隙間に形成される潤滑油膜（動圧溝の動圧作用によって形成される潤滑油膜）によって、軸4はホワール等の不安定振動を生じることなく、軸受面1bに対して非接触支持される。軸受隙間にしみ出した油Oは、軸4の回転に伴う発生圧力により、主に軸受面1bの表面開孔から軸受本体1aの内部に戻り、軸受本体1aの内部を循環して、再び軸受面1b及びチャンファ一部付近から軸受隙間にしみ出す。

【0014】図1に示す多孔質含油軸受1の軸受本体1aは、例えば銅又は鉄、あるいはその両者を主成分とする金属粉末を圧縮成形し、さらに焼成して得られた図12に示すような円筒形状の焼結金属素材1'に対して、例えばサイジング→回転サイジング→軸受面成形加工を施して製造することができる。

【0015】サイジング工程は、焼結金属素材1'の外周面と内周面のサイジングを行う工程で、焼結金属素材1'の外周面を円筒状のダイに圧入すると共に、内周面にサイジングピン（断面円形）を圧入する。回転サイジング工程は、断面略多角形のサイジングピン（断面円形のピンの外周面を部分的に平坦加工して、円周等配位置に円弧部分を残したもの）を焼結金属素材1'の内周面に圧入し、これを回転させながら内周面のサイジングを行う工程である。軸受面成形工程は、上記のようなサイジング加工を施した焼結金属素材1'の内周面に、完成品1aの軸受面1bに対応した形状の成型型21aを加圧することによって、軸受面1bの動圧溝1cの形成領域とそれ以外の領域（背1dおよび環状の平滑領域n）とを同時成形する工程である。この工程は、例えば以下のようなものである。

【0016】図5は、軸受面成形工程で使用する成型装置の概略構造を例示している。この装置は、焼結金属素材1'の外周面を圧入する円筒状のダイ20、焼結金属素材1'の内周面を成形するコアロッド21、焼結金属素材1'の両端面を上下方向から押さえる上下のパンチ22、23を主要な要素として構成される。図5(b)に示すように、コアロッド21の外周面には、完成品の軸受面1bの形状に対応した凹凸状の成型型21aが設けられている。成型型21aの凸部分21a1は軸受面1bにおける動圧溝1cの領域を成形し、凹部分21a2は動圧溝1c以外の領域（背1dおよび環状の平滑領域n）を成形するものである。成型型21aにおける凸部分21a1と凹部分21a2との段差（深さH）は、軸受面1bにおける動圧溝1cの深さと同程度（例えば

2〜5 $\mu$ m程度）で微小なものであるが、図面ではかなり誇張して図示されている。

【0017】ダイ20への圧入前の状態において、焼結金属素材1'の内周面とコアロッド21の成型型21a（凸部分21a1を基準）との間には内径すきまTがある。内径すきまT（直径量）の大きさは例えば50 $\mu$ mである。焼結金属素材1'の外周面のダイ20に対する圧入代（外径しめしろS：直径量）は例えば150 $\mu$ mである。

【0018】焼結金属素材1'をダイ20の上面に位置合わせして配置した後、図6に示すように、上パンチ22およびコアロッド21を降下させ、焼結金属素材1'をダイ20に圧入し、さらに下パンチ23に押し付けて上下方向から加圧する。

【0019】焼結金属素材1'はダイ20と上下パンチ22・23から圧迫力を受けて変形を起こし、内周面がコアロッド21の成型型21aに加圧される。内周面の加圧量は、外径しめしろSと内径すきまTとの差に略等しく、内周面から所定深さまでの表層部分がコアロッド21の成型型21aに加圧され、塑性流動を起こして成型型21aに食い付く。これにより、成型型21aの形状が焼結金属素材1'の内周面に転写され、軸受面1bが図1に示す形状および寸法に成形される（同時に焼結金属素材1'の外周面もサイジングされる。）。

【0020】軸受面1bの成形が完了した後、図9に示すように、焼結金属素材1'にコアロッド21を挿入したままの状態の下パンチ23とコアロッド21を連動して上昇させ（図9②の状態）、焼結金属素材1'をダイ20から抜く（図9③の状態）。焼結金属素材1'をダイ20から抜くと、焼結金属素材1'にスプリングバックが生じ、その内径寸法が拡大するので（図7参照）、動圧溝1cを崩すことなく、焼結金属素材1'の内周面からコアロッド21を抜き取ることができる（図9④の状態）。これにより、軸受本体1aが完成する。尚、通常の真円軸受（軸受面に動圧溝を有しない焼結含油軸受）の製造工程では、図8に示すように、軸受面（内周面）のサイジングを行った後、焼結金属素材1'をダイ20'に圧入したままの状態、サイジングピン21'（断面円形：図5(b)に示すような成型型21aは有しない。）を上昇させて焼結金属素材1'の内周面から抜き、その後、下パンチ23'で焼結金属素材1'を押し上げてダイ20'から取出すようにしている。この手順を、傾斜状の動圧溝を有する軸受面の成形に用いると、サイジングピン（コアロッド）を焼結金属素材の内周面から抜き取る際に、動圧溝の形状を崩してしまう。

【0021】図10に、内径 $\phi$ 3、外径 $\phi$ 6、幅3mmの焼結金属素材1'に対して、上述した軸受面成形工程を行った時の、内径すきまTおよび外径しめしろSとスプリングバック量との関係を示す。同図に示すように、内径すきまTおよび外径しめしろSとスプリングバック



量との間には一定の相関関係があり、内径すきまTと外径しめしろSを特定すれば、その時のスプリングバック量も特定されることが理解できる。実験によれば、所定の深さH(2 $\mu$ m~3 $\mu$ m:成形される動圧溝1cの深さと略等しい。)において、スプリングバック量を4~5 $\mu$ m(直径量)程度に設定すれば、動圧溝1cを崩すことなく焼結金属素材1'をコアロッド21から抜き取ることができたので、この程度のスプリングバック量が得られるよう内径すきまTと外径しめしろSとを設定するのが望ましい。尚、焼結金属素材1'のスプリングバック量の半径量が深さHよりも大きい場合は、成型型21aを焼結金属素材1'の内周面に干渉させることなく離型することができるが、焼結金属素材1'のスプリングバック量の半径量が深さHよりも小さく、成型型21aが焼結金属素材1'の内周面に多少干渉する場合であっても、焼結金属素材1'の材料弾性による拡張量(半径量)を付加して、動圧溝1cを崩すことなく成型型21aを焼結金属素材1'の内周面から離型できれば良い。従って、上記の実験結果に基づく寸法設定は一例であり、これによって本発明が限定的に解釈されるものではない。

【0022】なお、軸受面1bの成形工程が完了した後、軸受面1bを通常のサイジングピン(断面円形)を用いてサイジングしてもよい。この場合、軸受面1bにおける背1dおよび平滑領域nがサイジングピンによってサイジングされることにより、それら領域の表面開孔率は動圧溝1cの形成領域の表面開孔率よりも小さくなる。また、軸受面の成形工程において、成型型によって動圧溝の形成領域のみを成形し、その後、動圧溝の形成領域以外の領域をサイジング(断面円形のサイジングピンを使用)または回転サイジング(断面円形のピンの外周面を部分的に平坦加工して、円周等配位置に円弧部分を残したサイジングピンを使用)によって仕上げることも可能である。

【0023】以上のような工程を経て軸受本体1aを製造し、これに潤滑油又は潤滑グリースを含浸させて油を保有させると、図1に示す形態の動圧型多孔質含油軸受1が完成する。

【0024】真円軸受(軸受面に動圧溝を有しない焼結含油軸受)と上記方法によって製造した動圧型多孔質含油軸受(焼結含油軸受)を用いて軸振れ性能の比較実験を行った。実験は、図13に示すようなCD-ROM実機モータに試験軸受を組み込み、市販のCDを実装して、回転数に対する軸振れを測定したものである。その結果を図11に示す。同図からも真円軸受に比べ、実施形態の動圧型多孔質含油軸受が軸振れの抑制に有効であることが理解できる。

【0025】上記の実施形態は、焼結金属素材1'に対して軸受面成形を行うものであるが、この他にフォーミング工程において軸受面成形を行うこともできる。フォ

ーミングは、外型の内側に内型となるフォーミングピンを挿入し、内型と外型の間に粉末材料を充填した後、軸方向に加圧圧縮して円筒状に成形する工程である。このフォーミング工程において、フォーミングピンの外周面に図5(b)に示すような成型型を形成しておくことによって、フォーミングと同時に成形品(圧縮成形体)の内周面に図1に示すような形状の軸受面を成形することができる。また、加圧圧縮後、圧縮成形力を除去すれば成形品(圧縮成形体)のスプリングバックを利用して成形品(圧縮成形体)をフォーミングピンから抜くことができ、この時に軸受面の形状が崩れることもない。粉末材料は金属粉末材料で、例えば銅又は鉄、あるいはその両者を主成分とするものである。フォーミング後の成形品は、焼成した後、サイジング工程、油の含浸工程等を経て製品化される。

【0026】以上の説明では、多孔質素材又は圧縮成形体のスプリングバックを利用して軸受面の成型型を離型する場合を例示しているが、その他に、成型型を弾性的に縮径可能な構造とし(例えば成型型をスリットによる分割構造とする。)、軸受面の成形後、成型型を弾性的に縮径させて離型するようにしても良い。また、軸受面の形状(動圧溝の形状)に応じて、成型型の形状を変えることによって、種々の形状の軸受面を同様にして成形することができる。さらに、1つの軸受本体の内周面に複数の軸受面を軸方向に離隔して形成する場合も、外周面に複数の成型型を軸方向に離隔して形成したコアロッドやフォーミングピンを用いることによって、複数の軸受面を同時成形することができる。

【0027】

【発明の効果】本発明によれば、動圧溝の形成領域を成形するための第1成型部と動圧溝の形成領域以外の領域を成形するための第2成型部とを有する成型型を用いて、軸受面の全領域を同時成形するので、傾斜状の動圧溝を有する軸受面の成形加工を簡易な設備で、少ない工数で、かつ、精度良く行うことができる。また、軸受本体のフォーミングと軸受面成形とを同時に行うことも可能であるので、生産性の向上とコスト低減の点でも有利である。

【0028】本発明の製造方法によって製造された動圧型多孔質含油軸受は、軸受面の成形精度が高く、しかも、動圧溝の形成領域を含む軸受面の全領域に表面開孔が分布し、軸受本体の内部と軸受隙間との間の適切な油の循環が確保されるので、潤滑油膜の形成効果が高く、良好かつ安定した軸受機能を有すると同時に、高い耐久寿命を有する。

【図面の簡単な説明】

【図1】実施形態の製造方法によって製造された動圧型多孔質含油軸受の一形態を示す縦断面図である。

【図2】多孔質含油軸受を組み込んだモータを概念的に示す縦断面図である。

【図3】動圧型多孔質含油軸受の他の実施形態を示す縦断面図である。

【図4】動圧型多孔質含油軸受で軸を非接触支持する際の、軸方向断面での油の流れを模式的に示す図である。

【図5】図5(a)は軸受面の成形加工に使用する成形装置の概略を示す縦断面図、図5(b)は軸受面を成形する成形型を示す側面図である。

【図6】軸受面の成形工程を示す図である。

【図7】軸受面の成形工程を示す図である。

【図8】従来の真円軸受における軸受面の成形工程を示す図である。

【図9】実施形態の軸受面の成形工程を示す図である。

【図10】内径すきま及び外径すきまとスプリングバック

量との関係を示す図である。

【図11】従来の真円軸受と実施形態の動圧型多孔質含油軸受を使用した場合の、軸振れを比較試験した結果を示す図である。

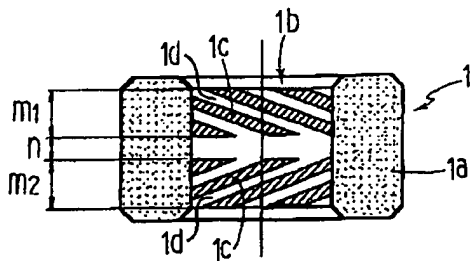
【図12】焼結金属素材を示す縦断面図である。

【図13】軸振れの比較試験に使用した実験装置を概念的に示す縦断面図である。

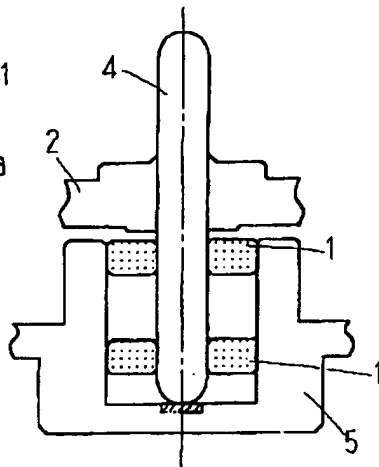
【符号の説明】

- 1 動圧型多孔質含油軸受
- 1a 軸受本体
- 1b 軸受面
- 1c 動圧溝
- 21a 成形型

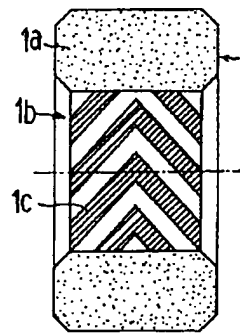
【図1】



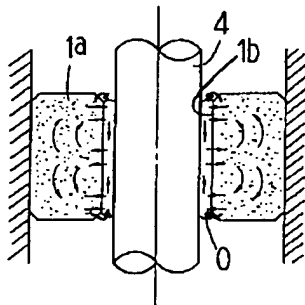
【図2】



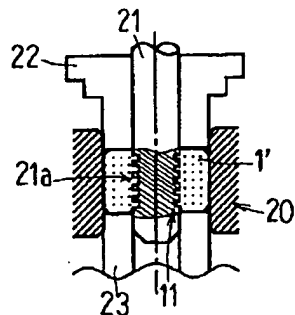
【図3】



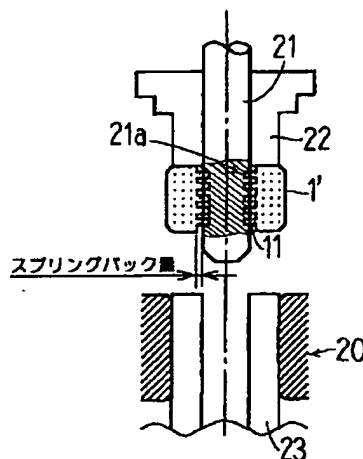
【図4】



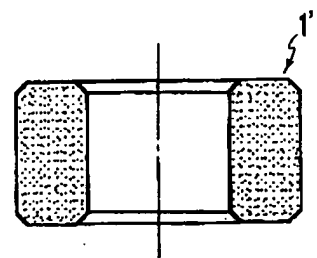
【図6】



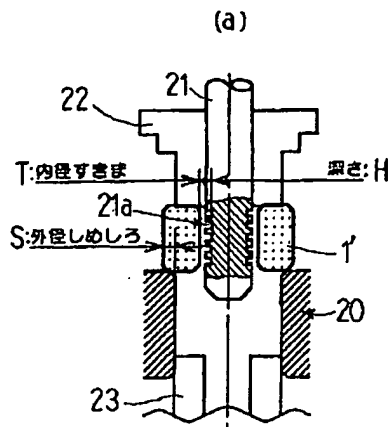
【図7】



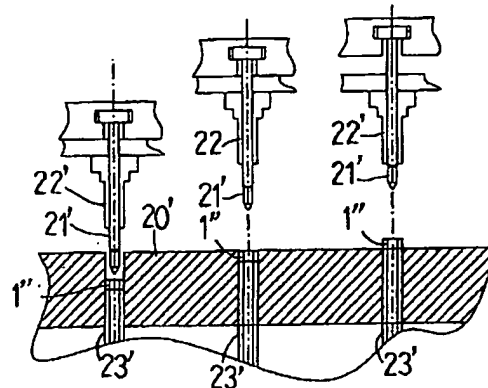
【図12】



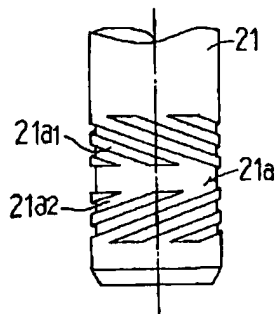
【図5】



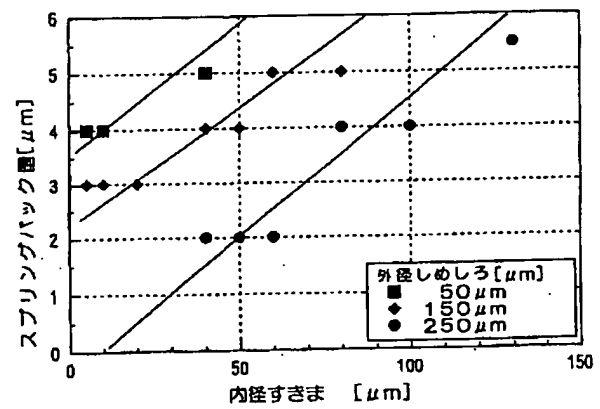
【図8】



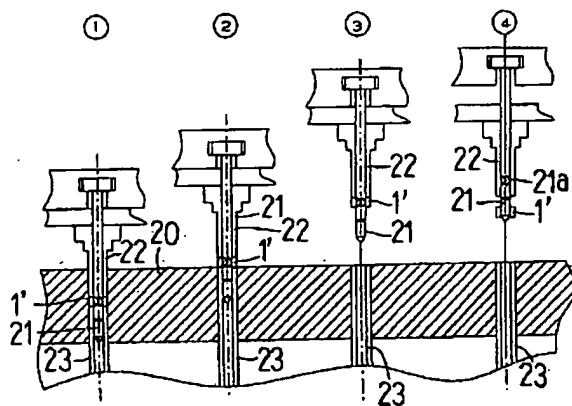
(b)



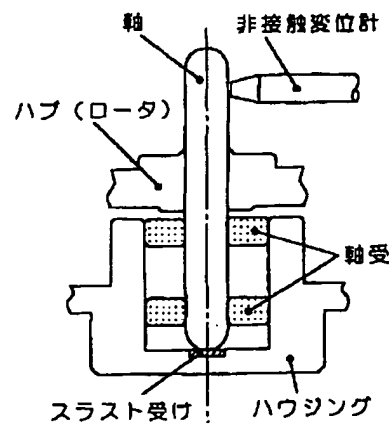
【図10】



【図9】



【図13】



【図11】

